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VEGETATION STUDIES IN NORTH-WEST VICTORIA
II. THE HORSHAM AREA

By D. J. Connor

Botany Department, University of Melbourne

Summary

The soil and vegetation interrelationships of an area of the Wimmera Region of Victoria are discussed. The original vegetation formations of the area have been reconstructed and mapped from remnants preserved along road reserves. Four savannah woodland communities, *Eucalyptus largiflorens* association, *E. hemiphloia* association, *E. leucoxylon* asociation, and *Casuarina leuhmannii* association, intergrade considerably to comprise the vegetation of the major part of the area. Because of the extensive clearing that has been undertaken, it is often difficult to distinguish the original areas of savannah woodland from the former grassland formation, *Stipa-Danthonia* association.

Introduction

The soils and vegetation of an area of 300 square miles of the Victorian Wimmera Region were surveyed from all passable roads and from many traeks. The area is located on aerial photomap Horsham 880 and is shown inset on the map of Vietoria (Fig. 1). No aecount of the vegetation of the Wimmera is avail-

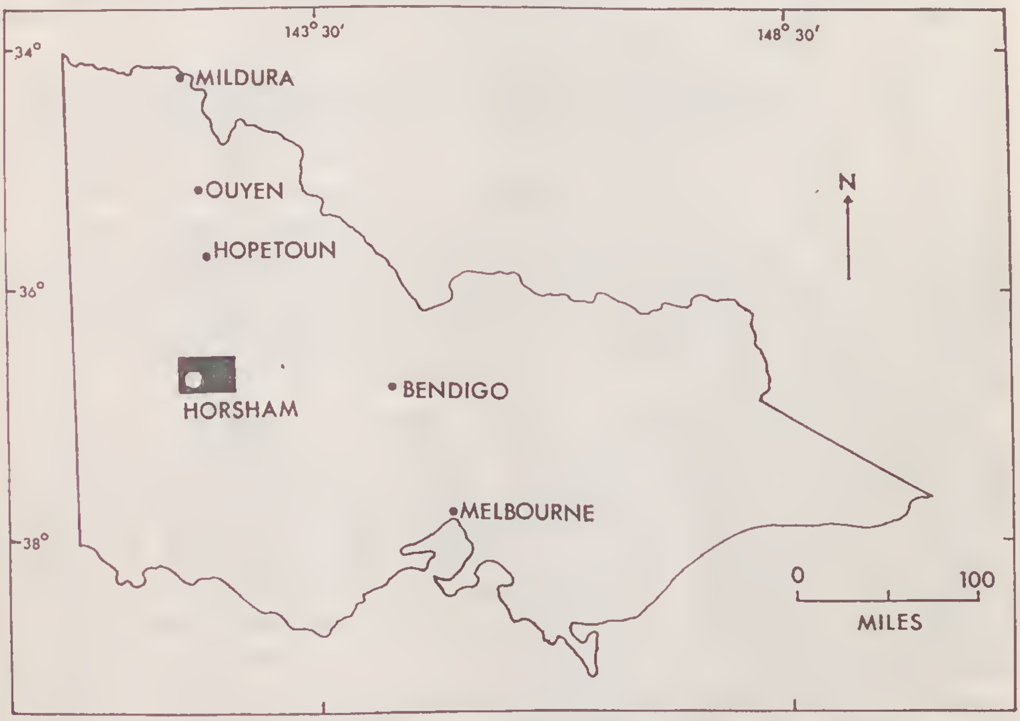

Fig. 1—Location of the area.

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able, although various publications (Leeper 1957; Skene 1954, 1959) have made passing comments about the savannah woodland communities which comprised a great part of the area. In South Australia, a survey near the Victorian border (Specht 1951) dealt in detail with country with many similarities.

Large scale clearing has resulted in the removal of most of the original vegetation. At the present time one of the most conspicuous species over much of the area is *Eucalyptus cladocalyx* F. Muell. (sugar gum), a South Australian endemic, which was extensively planted at the beginning of this century. It is exceptionally difficult, therefore, to delineate the distribution patterns of the native tree species. Close interrelationships of the soils of the area are a conspicuous feature of the landscape and mapping of their variation is difficult.

Geology and Physiography

During Lower Cretaceous times, earth movements caused the formation of the Murray Basin in South Australia and SE. Victoria. They continued into the early Tertiary and the Basin increased in size to include part of the Wimmera. At this time a bedrock fault situated 6 miles W. of Dimboola and trending NNW. prevented further easterly invasion of the sea. However, by Mid-Tertiary, subsidence of both E. and W. blocks enabled the Gulf to extend across the Dimboola Fault. Bore logs show that 420 ft of the Lower Cretaceous carboniferous sands and clays found at Nhill have no equivalent at Kewell on the high E. block (Anon. 1961).

In Pliocene times gradual uplift caused the sea to retreat. The NNW. ridges, which are a noticeable feature of the W. Wimmera and to a lesser extent of the E. Wimmera, are considered to be stranded coastal dunes of the retreating Murray Gulf (Blackburn 1962a). Two such dunes occur in the study area. They are situated approximately one mile apart and govern the course of the Yarriambiac Ck from Jung northwards towards Hopetoun.

Estuarine clays and sands were deposited over the greater part of the area by rivers and lakes which drained the newly exposed surface. Blackburn (1962b) considers that the distribution of the Wimmera clay soils indicates the location of an earlier Glenelg R. S. of the present town of Horsham. The river altered its course when the exposed plain was uplifted and tilted to the north. This movement probably occurred along the Dimboola Fault. The Murray R. came to occupy its present course, while its lower reaches became the present Glenelg R. and the upper reaches the Wimmera R. By a reversal of flow resulting from the same tilting phenomenon, the Wimmera R. occupied a former southward flowing river valley between Quantong and Jeparit. The same movement probably accounts for the northward flowing courses of the Yarriambiac and Dunmunkle Ck which are effluents of the Wimmera R.

In the Pleistocene and Recent Periods addition of wind borne and saltation material from the west have caused the formation of characteristic structures—lunettes, which are a common feature of the E. margins of now dried-up lakes. The lunettes associated with the Wimmera R. are sandy, indicating that in the past this river was more active and carried a greater sedimentation load than at the present time. Slowing down of the river, where it makes a sharp turn to the north at Quantong, could result in the deposition of sandy material on the E. bank. Such materials would then be transported under the action of the prevailing westerly winds, providing the materials from which the lunettes may have been formed.

The presence of laterite in the stranded coastal dunes near Jung shows that pluvial periods have been a feature of the immediate past climate. A quarry 2 miles N. of Dooen reveals friable black soil 4 ft deep, sharply overlying laterized sandstones. Presumably the old Pliocene surface was subjected to laterization during a pluvial period and later, under even wetter conditions, became a basin of deposition into which the parent material of the now exposed black friable soil was deposited. This area is considered to be one of the most recently exposed areas.

The land surface slopes gently to the north and two northward flowing effluents of the Wimmera R. have arisen. One of these, the Yarriambiac Ck, arises in the area and terminates in L. Coorong near Hopetoun. It does not flow continuously, but is dependent upon high winter-spring levels of the Wimmera R. for replenishment. From Jung to Hopetoun the creek flows in a broad, well-defined valley between the dunes previously mentioned. Before it enters this valley at Jung, water can easily escape the normal creek course. Apparently the S. extremities of the dunes have been eroded away by lateral planation across the flood plain of the Wimmera R. In wet years water spreads both E. and W. To the east it floods the country S. of Murtoa around 'Black Fellas' Waterholes', joining up with temporary creeks in that area. To the west the water enters Darlot's Swamp. When this swamp overflows, water returns to the south across the low land to the east of Longeronong Agricultural College, and finds its way back to the Wimmera R. approximately 8 miles downstream from where it originated as an effluent.

The flatness of the area and the precarious drainage relationships are clearly illustrated by this example. Shallow expanses of water lying over large areas are not uncommon, and were it not for surfaced roads, many areas of the Wimmera would be impassable to motor vehicles for most of the winter and early spring months.

Climate

Data from the Commonwealth Bureau of Meteorology (Melbourne) show a range in annual rainfall from 17·5″ at Horsham to 15·7″ at Jung. Fig. 2 summarizes meteorological data for Horsham. 40% of the rainfall falls in the summer and autumn months. Early and late frosts do occur, giving an average frost-free period of 207 days.

Soils

In general, the soils have developed on alluvial and lacustrine deposits of the drainage system of the Pliocene Murray Basin Plain. The only exceptions are the soils formed on the two parallel stranded coastal dunes which represent an older Pliocene land surface. The boundary of these latter soils is not sharply defined, for they intergrade with the alluvial deposits. The effect of the dunes is more pronouced on the country to the east of Jung, an expression of the dominance of westerly winds. Here, for some 6 to 8 miles, there is a strong inter-mixing of light-surfaced red brown earth (R.B.E.) soils with grey and brown soils of heavy texture (G.B.S.H.T.) (nomenclature per Stephens 1956). Even farther to the east the soils between Murtoa and Rupanyup are the more typical, self-mulching G.B.S.H.T. of the Wimmera plains. To the south-east of Murtoa, Pleistocene and Recent sediments contained a predominance of coarser material, most likely a reflection of a more vigorous drainage pattern—rivers and streams as opposed to lakes. On these sediments R.B.E., G.B.S.H.T., and transitional soils are closely intermixed.

Previous work on the soils of the Victorian Wimmera is limited to two small areas (Skene 1954, 1959) located 5 miles W. of Horsham and 8 miles N. of Murtoa respectively. Both of these surveys show the close interrelationships be-

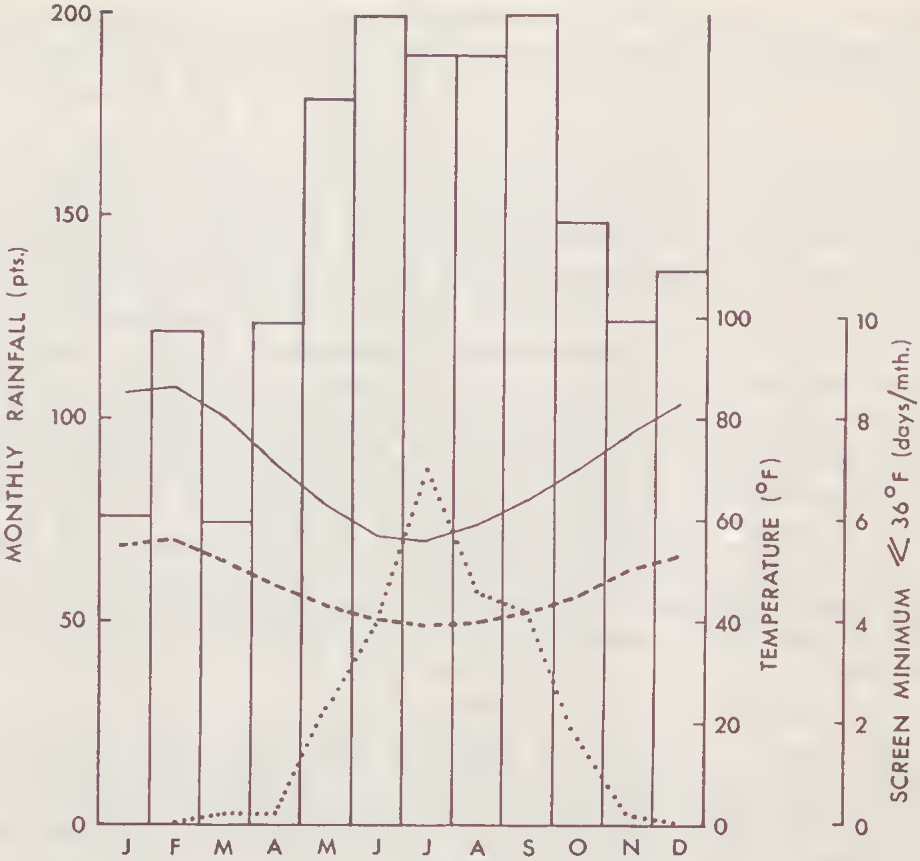

FIG. 2—A summary of climatic data for Horsham. Histogram of monthly rainfall. Mean monthly maximum (——) and mean monthly minimum (– – –) temperatures, and the monthly frequency of screen temperatures equal to or less than 36°F (···).

ween members of the Great Soil Groups, the R.B.E. and the G.B.S.H.T. Even though each report covers only 5 square miles, and in both cases detailed work was required for proposed irrigation schemes, it was found necessary to use soil complexes for mapping and description. From a pedological viewpoint there is a great range of parent materials, all are sediments but mechanical and probably chemical composition vary greatly over the area as a whole.

Since the area shows little topographical variation, climatic variations are small and hence vegetational changes clearly follow soil variation. Leeper (1957) justly cautioned the use of vegetational criteria in soil mapping because climate, as well as soil, is important in governing the distribution of vegetation. He uses as an example the vegetation of the Victorian Wimmera, pointing out that buloke (*Casuarina luehmannii*) grows over a great portion of the area, and yet the gilgai soils between Glenorchy and Rupanyup are not held as highly in esteem as are the soils under buloke in other areas. A better example is needed to prove his point, for in this area between Glenorchy and Rupanyup a prominent additional species, yellow gum (*Eucalyptus leucoxylon*), is present. This tree which is characteristic of R.B.E. soils in South Australia (Specht & Perry 1948, Specht 1951), and which extends on to solodic soils S. of Glenorchy, gives an immediate clue to a soil difference. Actually the soils in this area have R.B.E. tendencies and true G.B.S.H.T. are rare. The important point here is that a knowledge of the complete range of species is essential, and then the important or critical species, if one occurs, can be discovered. In this case, buloke is an ecological wide; yellow gum can be regarded as the indicator species.

Although topographical information is not available, stock and domestic water channels indicate that the area N. of the Wimmera R., between Pimpinio and Dooen, is low-lying and probably one of the most recently exposed areas—a product of an internal drainage system. The soils of this area, the 'Kalkee Plain', differ from the more typical G.B.S.H.T. found on either side of the Western Highway SE. of Horsham, on which most previous observations have been made. Vegetational differences reflect this also, for although the area S. of the river previously carried a savannah woodland of grey box (*Eucalyptus hemiphloia*) and buloke, the 'Kalkee Plain' was a true grassland formation. On this 'plains' area, surface soils of puff and hollow in the gilgai complex are high in lime and extremely self-mulching. Trees, notably sugar gum, can be established if watered during the first few summers, but under virgin conditions only perennial grass species could persist through the summer months. These soils are more easily cultivated, and arable more quickly after rain than their counterpart of the woodland areas S. of the river. This soil difference is reflected in the farming practice, for wheras cereal production is intense on the self-mulching soils, the non-friable G.B.S.H.T. are used predominantly for pasture production.

Gilgai, with their colour and microtopographic variations, are a noticeable feature of almost all soils of the area. All the G.B.S.H.T. show gilgai structure as do also some transitional R.B.E. The form of the gilgai can vary from well-defined puffs and hollows, a matter of 2 yds apart and with 2 to 3 ft difference in elevation, through a whole range to the case where puffs are broad (30 ft) and barely distinguishable. Blackburn & Gibbons (1956) showed in Kowree Shire that some soils of the hollows in the gilgai complex were solonetzic. No such soils were seen in this area. All puff soils are self-mulching but not so the soils of shelf or hollow. In some cases there is no evidence of a hollow being present at all. Constant cultivation has caused 'ironing out' of most gilgai structures; however, observation on roadsides indicates that they were extensive over the whole of the Wimmera region.

Descriptions of representative profiles are given in Appendix 1. Skene (1954, 1959) provides more precise information on the physical and chemical characteristics of the soils of the area.

Vegetation

The original vegetation of the Wimmera consisted for the most part of a savannah woodland sub-formation (terminology per Wood & Williams 1960), with *Eucalytus hemiphloia* (grey box), *E. largiflorens* (black box), *E. leucoxylon* (yellow gum), *E. camaldulensis* (red gum), and *Casuarina luehmannii* (buloke) as the dominants. Most combinations of these species can be found. In the E. section of the Wimmera, at least, a grassland formation did exist, and one of these, the 'Kalkee Plain', is situated between Pimpinio and Dooen in the area studied. Another is found between Murtoa and Rupanyup, and a third, the 'Lallat Plain', occurs E. of Rupanyup.

Savannah Woodland Sub-Formation

(i) Dominant Speeies:

All savannah woodland eommunities intermix with eaeh other, but insuffieient vegetation remains to use a quantitative approaeh to separate the eommunities involved in the vegetational continuum (e.g. positive interspeeifie eorrelation as was used in the Beulah area (Connor 1966). Therefore, it seems preferable to diseuss the auteeology of eaeh dominant speeies, mentioning interrelationships as they arise.

Eucalyptus camaldulensis (red gum)

This speeies does not extend beyond the watereourses and swamps of the area. In these loealities it forms a well-developed savannah woodland, often in assoeiation with *E. largiflorens* (blaek box). *E. camaldulensis* fringes the Wimmera R. but is not eommon along the Yarriambiae Ck, being present only in plaees where permanent or near permanent waterholes oeeur. In the vieinity of 'Blaek Fellas' Waterholes' and also in the Dooen Swamp there is evidenee of regrowth of *E. camaldulensis*. This is probably related to the very wet winter and spring of 1956, when eonditions suitable for germination oeeurred.

The distribution of this speeies is insuffieient for it be ineluded on the vegetation map of the area (Fig. 3).

Eucalyptus largiflorens (blaek box, flooded box)

Blaek box is eonfined to areas subjeet to infrequent flooding. It is more drought resistant than red gum and ean survive on soils whieh dry out and eraek deeply in summer, provided that this is an uneommon oeeurrenee, and that during the winter months the soil is again fully reeharged with water. In some situations it forms a serubby eommunity whieh ean hardly be termed a woodland. Typieally, however, it is a well-grown tree with a woodland form. Lignum (*Muehlenbeckia cunninghamii*) is eommonly assoeiated with it on wetter sites.

Most suitable areas for the growth and development of blaek box are found in assoeiation with watereourses, or with low-lying land whieh is generally wet in winter and spring. However, it does oeeur in small poekets or as single trees at points of impeded drainage in generally better drained land. Sueh positions oeeurred in the grassland formation, and indieated to the early settlers the appropriate plaees at whieh to eonstruet water storage struetures.

Eucalyptus hemiphloia var. *microcarpa* (grey box)

This speeies is often eonfused with *E. largiflorens*. The two speeies hybridize and this makes identifieation diffieult in some eases. *E. largiflorens* has a spreading habit with branehes which often toueh the ground. *E. hemiphloia* on the other hand is typieally half-barked, with a lighter basal bark, has an upright habit and no tendeney to have drooping branehes.

E. hemiphloia grows in assoeiation with *Casuarina luehmannii* as a savannah woodland S. of the Wimmera R. It is not found with *E. largiflorens* along the Yarriambiac Ck but grows with *C. luehmannii, E. largiflorens,* and *E. leucoxylon* in the vieinity of 'Blaek Fellas' Waterholes'. The eontrolling feature appears to be a requirement for a slightly better drained soil than those upon whieh *E. largiflorens* flourishes.

E. hemiphloia extends eastwards on the red brown earth soils of north-eentral Vietoria.

Eucalyptus leucoxylon (yellow gum)

This is not a common species. It is widespread, however, and is found in locations where the soil has a lighter surface texture than the usual G.B.S.H.T. provide. It occurs alone on the sandy lunettes associated with the Wimmera R. and to the east, between Glenorchy and Rupanyup, it accurately delineates the R.B.E. and transitional soils with their suitable moisture relationships.

E. leucoxylon extends on to the solodic soils S. of Glenorchy.

Casuarina luehmannii (buloke)

This is the most widespread species. It grows under a wide range of soil conditions and can readily be found in association with all the tree species mentioned above. It grows alone on the country bordering the Yarriambiac Ck, and in some areas to the east of the creek between Jung and Murtoa. The soils in these situations are R.B.E. derived from the two stranded coastal dunes which border the creek. To the early settlers this 'buloke' land presented a contrast to the grassland ('plains') found both to the east and to the west. The earliest survey plans (Central Plans Office, Melbourne) have notes to the effect that this 'sandy soil timbered with Oak' was regarded as 'good agricultural land'. Apparently the settlers considered the 'plains' poor land. If it could not support trees, then how could it be expected to grow crops or pastures? Consequently, none of the earliest land selections is located on 'plains' country. This classification has since been proved to be disastrously wrong, for wheat yields of 60-70 bushels per acre are commonplace on the black 'plain' country; the red sandy soils, which once carried pure buloke, produce crops in the order of 18-20 bushels per acre and suffer from surface sealing problems.

As is the case with black box, buloke does not always occur in a savannah woodland sub-formation (TG (m.d.)). In some locations the structure of the community is more aptly described as a sclerophyll scrub sub-formation (T/S_1S_2(d)). Since most of the area is now cleared of timber it is not known how extensively buloke grew in this manner. Probably these occurrences were rare or they would have been noted on the early survey maps. As it is, most notes refer to 'lightly timbered country'.

Other Tree Species—

Other species of only limited occurrence are *E. viminalis* (manna gum) on the sandy lunette which forms the Horsham Golf Club, *Banksia marginata* (honeysuckle) and *Callitris preissii* (pine) found on the Horsham lunette, on another lunette at Dooen, and on a sandy area amidst the *E. hemiphloia-E. leucoxylon* savannah woodland adjacent to 'Black Fellas' Waterholes'.

E. melliodora A. Cunn. (yellow box), though not recorded in the study area, is found in country to the immediate east. It is commonly found in sites where sand or gravel lenses occur near the surface (G. Blackburn pers. comm.).

(ii) Associations:

An attempt to describe the associations of the savannah woodland sub-formation has been made in Table 1. The difficulty is that a great part of the study area is a close mixture (ecotone) between four associations which, as pure stands, occupy significant areas in other parts of Australia. These are *E. largiflorens* association, *E. hemiphloia* association, *E. leucoxylon* association, and *Casuarina luehmannii* association. Another possible treatment (Beadle & Costin 1952) would be to call each separate admixture an association. In this case the 17 possible combinations

Table 1

The Ecological Relationships of the Vegetation Around Horsham

Formation	Community	Structural Formula	Rainfall (in. per annum)	Soil	Comments	
Woodland .. .. (Sub-formation Savannah Woodland)	*E. camaldulensis* association	TG(m.d.)	15·5–17·5	G.B.S.H.T., R.B.E., transitional soils	restricted to positions where frequent and prolonged floodings occur	
	E. largiflorens association	TG(m.d.)	15·5–17·5	G.B.S.H.T., R.B.E., transitional soils	restricted to positions where infrequent floodings occur	These species are found together over a large portion of the area following small variations in soils and minor topographic fluctuations
	E. hemiphloia association	TG(m.d.)	17·0–17·5	G.B.S.H.T., transitional soils	as a pure stand restricted to heavy soils which are not flooded and which are not self-mulching	
	Cas. luehmannii association	TG(m.d.)	16·5–15·5	R.B.E. of the Jung dune system	found only as a pure stand on soils developed on the Pliocene land surface	
	E. leucoxylon association	TG(m.d.)	17·0–17·5	R.B.E. and transitional soils with a shallow sandy surface	controlling feature is a requirement for a light textured surface soil over a heavy sub-soil	
	Callitris preissii–Banksia marginata association	TG(m.d.)	17	deep sands of isolated lunettes	of minor occurrence and restricted to three small patches of deep sand probably originating as sediment from the Wimmera River	
Grassland	*Stipa–Danthonia* association	G.	16·5–15·5	G.B.S.H.T.	restricted to those G.B.S.H.T. with a highly self-mulching surface soil	

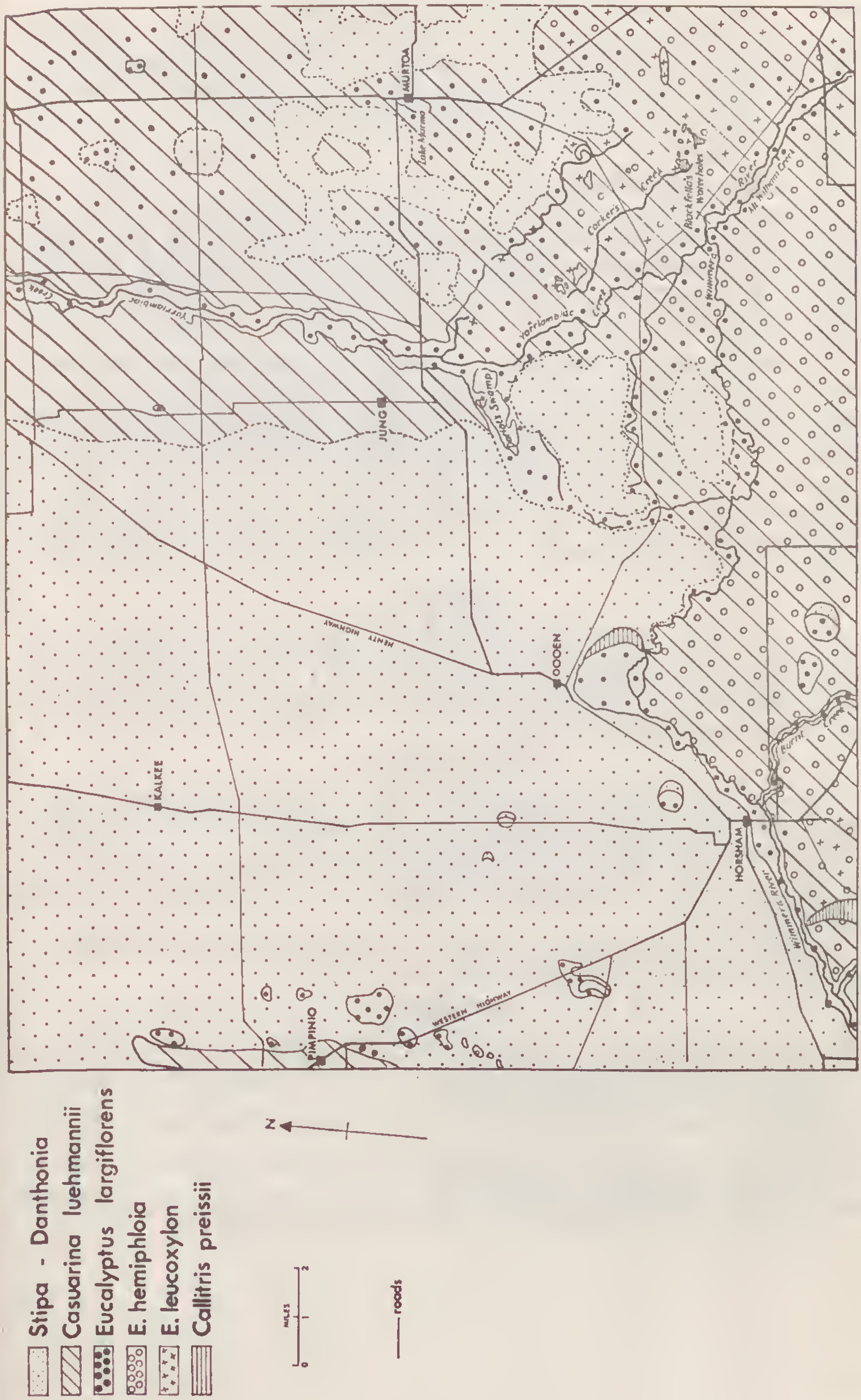

FIG. 3—Vegetation map for the Horsham area.

of the four species would represent 17 associations. These would then be grouped into one or more alliances, the name given to groupings employed as mapping units. This approach is not suitable for the area studied here, but could be useful if a larger area of the Wimmera were considered. It is certainly suited to areas in which the pattern of vegetational changes is difficult to record.

GRASSLAND FORMATION (G)

(i) *Stipa-Danthonia* association:

This formation is restricted to areas of highly self-mulching soils. These are the 'plains' areas of the original survey records, although they are now often vegetationally indistinguishable from adjacent areas of savannah woodland. Observations on roadsides indicate that the soils associated with this formation show a subdued microtopographic relief of gilgai in which puffs are broad and often barely distinguishable.

The formation is described under a single association, the *Stipa-Danthonia* association. In describing it in this way, due consideration has been given to the possibility that *Themeda australis* (kangaroo grass), as has been shown for other grasslands (Moore 1959), could have been the pre-settlement dominant. In such areas it is possible to find the original *Themeda* persisting in relatively undisturbed areas such as railway reserves (Patton 1936, Groves 1964). Ecological work is often restricted to these remnants. However, in the Horsham Area as described in this survey, no specimens of *Themeda* have been discovered in either grassland or savannah woodland communities.

Discussion

The relationships which were noted in the previous section, together with information on soils, are summarized in Table 1, which is drawn up on the basis of the more easily defined plant associations of the area. Species lists for component associations are contained in Appendix 2. A vegetation map of the Horsham Study Area is presented in Fig. 3.

Acknowledgements

This work was undertaken as an initial step in a study of the ecological relationships of the yellow burr weeds (*Amsinckia* spp.) in Victoria. The whole project was financed by the Victorian Wheat Research Committee.

Mr J. H. Willis of the National Herbarium checked the identifications of the plant collection used in assembling Appendix 2. Miss J. Wood did the hand lettering on Fig. 3.

I would like to thank Dr R. L. Specht for his encouragement throughout the project and for his help in the preparation of this paper.

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Explanation of Plate

PLATE 59

Fig. a—*Eucalyptus leucoxylon* association.
Fig. b—*Casuarina luehmannii* association.

Appendix 1

Representative Soil Profiles from the Horsham Area

1. *Stipa-Danthonia* association (Grassland formation)
   2 miles E. of Pimpinio (roadside)
   (a) Gilgai depression
   0-4″ Grey-brown (10YR5/2) (Munsell 1948) light clay, breaking down to fine granular aggregates when dry.
   4-24″ Dark grey (10YR4/1) medium clay of blocky structure, highly friable and with soft calcium carbonate concretions.
   24-48″ Dark grey (10YR4/1) medium clay of blocky structure, still friable but calcium carbonate less obvious.
   48-62″ Gradual transition to greyish-brown (2·5Y5/2) medium clay high in calcium carbonate.
   62″ Continuing.

   (b) Gilgai puff—(15 ft from 1 (a))
   0-4″ Grey brown (10YR5/1) light clay, readily breaking down to fine granular aggregates when dry. Many fine and few large (6 mm) calcium carbonate concretions. Deep cracks penetrate to the subsoil.
   4-24″ As for 1 (a).
   etc.

2. *Casuarina luehmannii* association (Savannah woodland sub-formation)—8 miles NW. of Murtoa (roadside)
   0-3″ Red-brown (5YR4/4) sandy loam, surface sealing with platey structure. Ironstone pebbles present.
   3-6″ Yellowish-red (5YR5/6) sandy clay loam with sandy accessions from the surface into cracks in subsoil.
   6-18″ Red-brown (5YR4/4) heavy clay with prismatic structure.
   18-42″ Yellowish-red (5YR5/6) clay slightly mottled and with soft calcium carbonate concretions.
   42-68″ Lime decreasing.
   In some situations the profile stops abruptly as shallow as 6″ on to massive ironstone accumulations.

3. *E. hemiphloia* association (Savannah woodland sub-formation)
   2 miles ESE. of Horsham
   0-2″ Brown (7·5YR4/4) clay with small hard setting aggregates.
   2-10″ Grey (10YR4/1) heavy clay with blocky structure cracking deeply.
   10-30″ Heavy brownish-grey (2·5Y6/2) clay with blocky structure.
   30-50″ Medium brownish-grey (2·5Y6/2) clay with increasing fine calcium carbonate concretions.

4. *E. hemiphloia, Casuarina luehmannii, E. leucoxylon* (Savannah woodland sub-formation)
   4 miles S. of Murtoa
   0-4″ Brown (7·5YR4/2) sandy loam with hard setting aggregates.
   4-18″ Yellow-brown (2·5Y6/4) medium clay with medium blocky structure.
   18-39″ Brownish-grey (2·5Y6/2) medium clay with increasing calcium carbonate present in more or less isolated pockets.
   39-51″ Mottled yellow-brown (2·5Y6/4) medium clay with decreasing calcium carbonate-blocky structure.

APPENDIX 2

A List of Plants Recorded Growing in the Component Associations

1. *E. hemiphloia* association
2. *E. largiflorens* association
3. *Casuarina luehmannii* association
4. *E. leucoxylon* association
5. *Callitris preissii–Banksia marginata* association
6. *Stipa–Danthonia* association

An asterisk before a species name indicates that the species is introduced.

A set of herbarium specimens for most of the species recorded has been deposited in the Herbarium, Botany Department, University of Melbourne.

	1	2	3	4	5	6
Marsileaceae						
Marsilea drummondii A. Br.	+	+	–	–	–	–
Cupressaceae						
Callitris preissii Miq.	–	–	–	–	+	–
Gramineae						
* *Ehrharta calycina* Sm.	–	–	–	–	+	–
* *Briza minor* L.	+	–	+	–	–	+
Distichlis distichophylla (Labill.) Fasset	–	+	–	–	–	–
Poa australis sp. agg.	+	–	–	+	–	–
* *P. bulbosa* L.	+	–	+	–	–	+
* *Lolium perenne* L.	–	–	–	–	–	+
* *L. rigidum* Gaudin	+	+	+	+	+	+
* *L. loliaceum* (Bory & Chaub.) Hand.-Mazz.	–	–	–	–	–	+
* *Bromus macrostachys* Desf.	–	–	–	–	–	+
B. arenarius Labill.	+	–	–	–	–	+
* *Hordeum leporinum* Link	+	+	+	+	–	+
* *H. hystrix* Roth	+	+	+	+	–	+
* *Avena fatua* L.	+	+	+	+	–	+
* *A. alba* Vahl	–	–	–	–	–	+
Amphibromus neesii Steud.	+	–	–	+	–	–
* *Koeleria phleoides* (Vill.) Pers.	–	–	+	–	+	–
* *Aira caryophyllea* L.	+	+	+	+	+	+
* *Phalaris minor* Retz.	+	–	–	–	–	–
Agrostis avenacea J. F. Gmel.	+	–	–	–	–	+
* *Polypogon monspeliensis* (L.) Desf.	–	–	–	–	+	–
* *Eragrostis elongata* (Willd.) J. F. Jacq.	–	–	+	–	–	–
Chloris truncata R.Br.	+	+	–	–	–	–
Cynodon dactylon (L.) Pers.	+	+	–	–	–	–
Phragmites communis Trin.	–	+	–	–	–	–
Danthonia geniculata J. M. Black	–	–	–	–	+	–
D. linkii Kunth	+	–	–	–	–	+
D. duttoniana A. B. Cashmore	+	–	–	–	–	+
D. setacea R.Br	–	–	–	–	–	+
D. caespitosa Gaudich	+	–	–	–	–	+
Stipa hemipogon Benth.	+	–	–	+	+	–
S. aristiglumis F. Muell.	+	–	–	–	–	+
S. variabilis D. K. Hughes	+	–	–	–	–	+
S. eremophila F. M. Reader	+	–	–	–	–	+
Panicum prolutum F. Muell.	+	+	+	–	–	–
* *Paspalum dilatatum* Poir.	+	+	–	–	–	–

APPENDIX 2—*continued*

	1	2	3	4	5	6
CYPERACEAE						
* *Cyperus eragrostis* Lam.	+	+	−	−	−	−
Scirpus nodosus Rottb.	−	−	−	−	+	−
Eleocharis acuta R.Br.	−	+	−	−	−	−
Lepidosperma carphoides F. Muell. ex Benth.	−	−	−	−	+	−
Carex inversa R.Br.	+	+	−	−	−	−
JUNCACEAE						
Juncus pallidus R.Br.	−	+	−	−	−	−
J. australis Hook. f.	+	+	−	−	−	−
J. filicaulis Buch.	−	+	−	−	−	−
J. radula Buch.	+	+	−	−	−	−
LILIACEAE						
Lomandra effusa (Lindl.) Ewart	−	+	−	−	−	−
Arthropodium minus R.Br.	+	−	−	−	−	+
Dichopogon strictus (R.Br.) J. G. Baker	+	+	−	−	−	−
Bulbine bulbosa (R.Br.) Haw.	+	+	−	−	−	+
Dianella revoluta R.Br.	+	−	−	−	+	−
IRIDACEAE						
* *Romulea rosea* (L.) Eckl.	+	−	−	−	−	+
CASUARINACEAE						
Casuarina luehmannii R. T. Baker	+	+	+	+	−	+
PROTEACEAE						
Banksia marginata Cav.	−	−	−	−	+	−
LORANTHACEAE						
Amyema linophylla (Fenzl) Van Tiegh.	−	−	+	−	−	−
POLYGONACEAE						
* *Polygonum aviculare* L.	+	+	+	−	−	+
Muehlenbeckia cunninghamii (Meissn.) F. Muell.	+	−	−	−	−	+
* *Rumex acetosella* L.	+	+	+	−	+	+
CHENOPODIACEAE						
Rhagodia nutans R.Br.	+	+	−	−	−	−
Chenopodium album L.	+	+	+	−	−	+
C. pumilio R.Br.	−	−	−	−	−	+
Atriplex semibaccata R.Br.	+	+	−	−	−	+
Bassia quinquecuspis (F. Muell.) F. Muell.	−	+	−	−	−	+
Kochia brevifolia R.Br.	−	+	−	−	−	−
K. excavata J. M. Black	−	−	−	−	−	+
K. aphylla R.Br.	−	−	−	−	−	+
Enchylaena tomentosa R.Br.	+	+	−	−	−	+
AMARANTHACEAE						
* *Amaranthus retroflexus* L.	−	+	−	−	−	+
* *A. albus* L.	−	−	−	−	−	+
Ptilotus exaltatus Nees	+	+	−	−	−	+
P. spathulatus (R.Br) Poir	+	−	−	−	−	+
P. macrocephalus (R.Br.) Poir.	+	+	−	−	−	+
PORTULACACEAE						
Portulaca oleracea L.	−	−	−	−	−	+
AIZOACEAE						
Carpobrotus aequilaterus (Haw.) N. E. Br.	−	−	−	−	+	−
CARYOPHYLLACEAE						
Spergularia rubra (L.) J. & C. Presl	+	+	−	−	−	−
* *Cerastium glomeratum* Thuill.	−	−	−	−	−	+
* *C. tetrandrum* Curtis	−	−	−	−	+	−
LAURACEAE						
Cassytha pubescens R.Br.	−	−	−	−	+	−
PAPAVERACEAE						
* *Papaver hybridum* L.	−	−	+	−	−	+
* *Fumaria micrantha* Lag.	−	+	−	−	−	+

APPENDIX 2—*continued*

	1	2	3	4	5	6
CRUCIFERAE						
* *Brassica tournefortii* Gouan	—	—	+	—	—	+
* *Diplotaxis tenuifolia* (L.) DC.	—	—	—	—	—	+
* *Sisymbrium orientale* L.	+	+	+	—	—	+
* *Conringia orientalis* (L.) Dumart.	+	—	—	—	—	+
* *Lepidium draba* L.	—	—	+	—	—	+
* *L. virginicum* L.	+	—	—	—	—	+
* *Raphanus raphanistrum* L.	+	—	—	—	+	+
PITTOSPORACEAE						
Bursaria spinosa Cav.	—	—	—	—	+	+
CRASSULACEAE						
Crassula macrantha (Hook. f.) Diels	—	—	—	—	+	—
ROSACEAE						
Acaena ovina A. Cunn.	—	+	—	—	—	—
A. anserinifolia (Forst. & Forst. f.) Druce	+	+	—	—	—	—
LEGUMINOSAE						
Acacia armata R.Br.	+	—	—	+	—	—
A. brachybotrya Benth.	—	—	—	—	+	—
* *Trifolium tomentosum* L.	+	—	—	+	—	+
* *T. glomeratum* L.	—	—	+	—	—	—
* *T. subterraneum* L.	+	—	+	—	—	+
* *T. arvense* L.	+	—	+	—	—	—
* *T. angustifolium* L.	+	—	—	—	—	—
* *T. campestre* Schreb.	+	+	—	—	—	+
* *Medicago minima* (L.) L.	+	+	+	+	—	+
* *M. truncatulata* J. Gaertn. (Syn. *M. tribuloides* Desr.)	+	+	+	+	—	+
* *M. sativa* L.	—	—	—	—	—	+
* *M. polymorpha* L. var. *ciliaris* (Ser.) Shinners	—	—	—	—	—	+
* *M. polymorpha* L. var. *polymorpha* (syn. *M. denticulata* Willd.)	+	+	+	+	—	+
* *M. scutellata* (L.) Mill.	—	—	—	—	—	+
* *M. minima* (L.) L.	+	+	+	+	—	+
* *Melilotus indica* (L.) All.	—	—	+	—	—	+
Swainsona microphylla A. Gray	—	—	—	—	—	+
S. procumbens (F. Muell.) F. Muell.	+	—	+	—	—	+
* *Vicia sativa* L.	+	—	+	—	—	+
LINACEAE						
Linum marginale A. Cunn. ex Planch.	+	+	—	—	—	—
OXALIDACEAE						
Oxalis corniculata L.	+	+	—	+	—	—
O. pes-caprae L.	—	—	+	—	—	+
GERANIACEAE						
* *Erodium cicutarium* (L.) Ait.	+	+	—	—	+	—
RUTACEAE						
Correa reflexa (Labill.) Vent.	—	—	—	—	+	—
EUPHORBIACEAE						
Euphorbia drummondii Boiss.	+	—	+	—	—	+
* *Chrozaphera tinctoria* (L.) Juss	—	—	—	—	—	+
SAPINDACEAE						
Dodonaea attenuata A. Cunn.	—	—	—	+	—	—
D. cuneata Sm.	—	—	—	+	—	—
DILLENIACEAE						
Hibbertia virgata R.Br. ex DC.	—	—	—	—	+	—
H. sericea (R.Br. ex DC.) Benth.	—	—	—	—	+	—
THYMELAEACEAE						
Pimelea glauca R.Br.	+	—	—	—	—	+
LYTHRACEAE						
Lythrum hyssopifolium L.	+	+	—	—	—	+

Appendix 2—*continued*

	1	2	3	4	5	6
Myrtaceae						
Eucalyptus viminalis Labill.	–	–	–	–	+	–
E. camaldulensis Dehnh.	–	+	–	–	–	–
E. hemiphloia F. Muell. ex Benth. var. *microcarpa* Maiden	+	–	–	+	–	–
E. leucoxylon F. Muell.	+	–	+	+	–	–
E. largiflorens F. Muell.	–	+	–	–	–	+
Leptospermum myrsinoides Schlecht.	–	–	–	–	+	–
L. lanigerum (Ait.) Sm.	–	–	–	–	+	–
Callistemon macropunctatus (Du M. Cours.) A. B. Court	–	–	–	–	+	–
Onagraceae						
Oenothera stricta Ledeb.	–	–	–	–	+	–
Haloragaceae						
Haloragis heterophylla Brongn.	+	+	–	–	–	+
Myriophyllum propinquum A. Cunn.	–	+	–	–	–	–
Umbelliferae						
Hydrocotyle peduncularis R.Br. ex A. Rich	–	+	–	–	–	–
Eryngium rostratum Cav.	+	+	–	–	–	+
Epacridaceae						
Acrotriche serrulata (Labill.) R.Br.	–	–	–	–	+	–
Astroloma conostephioides (Sond.) Benth.	–	–	–	–	+	–
Brachyloma daphnoides (Sm.) Benth.	–	–	–	–	+	–
Primulaceae						
* *Anagallis arvensis* L.	+	–	–	–	–	+
Menyanthaceae						
Nymphoides crenatum (F. Muell.) O. Kuntze	–	+	–	–	–	–
Convolvulaceae						
Convolvulus erubescens Sims	+	–	–	–	–	+
* *C. arvensis* L.	–	–	–	–	–	+
Boraginaceae						
* *Amsinckia hispida* (Ruiz. & Pav.) Johnst.	–	–	+	–	–	+
* *A. lycopsoides* Lehm.	–	–	+	–	–	+
* *A. intermedia* Fisch. and Mey.	–	–	–	–	–	+
* *Lithospermum arvense* L.	–	–	+	–	–	+
Labiatae						
Teucrium racemosum R.Br.	–	–	–	–	–	+
Westringia rigida R.Br.	+	+	–	–	–	–
Mentha satureioides R.Br.	+	+	–	+	–	–
* *Marrubium vulgare* L.	+	–	+	–	–	+
* *Salvia verbenaca* L.	+	+	–	+	–	+
* *Lamium amplexicaule* L.	+	–	+	–	–	+
Solanaceae						
* *Lycium ferrocissimum* Miers	+	–	+	–	–	+
Solanum nigrum L.	–	–	–	–	–	+
* *S. rostratum* Dunal	–	–	–	–	–	+
* *S. elaeagnifolium* Cav.	–	–	–	–	–	+
* *Datura stramonium* L.	–	–	–	–	–	+
Scrophulariaceae						
* *Parentucellia latifolia* (L.) Carvel	+	+	–	–	+	+
Myoporaceae						
Myoporum deserti A. Cunn. ex Benth.	–	–	+	–	–	–
Eremophila longifolia (R.Br.) F. Muell.	–	–	+	–	–	–
Plantaginaceae						
* *Plantago coronopus* L.	+	+	–	–	–	+
P. varia R.Br.	+	+	–	–	–	–
Rubiaceae						
Asperula conferta Hook. f.	+	+	–	+	–	+
* *Galium murale* (L.) All.	–	–	–	–	+	–

APPENDIX 2—*continued*

	1	2	3	4	5	6
CURCURBITACEAE						
* *Cucumis myriocarpus* Naudin	–	–	–	–	–	+
CAMPANULACEAE						
Wahlenbergia consimilis N. Lothian	+	+	–	+	+	–
Pratia concolor (R.Br.) Druce	+	+	–	+	–	–
GOODENIACEAE						
Goodenia heteromera F. Muell.	+	–	+	–	–	–
COMPOSITAE						
Solenogyne bellioides Cass. var. *gunni* (Hook. f.) Davis	+	+	–	+	–	–
Brachycome ciliaris (Labill.) Lessing var. *subintegrifolia* Davis	–	+	–	–	–	–
B. basaltica F. Muell. var *gracilis* Benth.	–	+	–	–	–	–
Minuria leptophylla DC.	+	+	–	–	–	–
Calotis scabiosifolia Sond. & F. Muell.	+	–	–	–	–	–
Vittadinia triloba (Gaud.) DC.	+	+	+	+	+	+
Helipterum corymbiflorum Schlechtendal	+	+	–	+	–	+
Helichrysum apiculatum (Labill.) DC.	+	+	–	–	–	+
H. leucopsidium DC.	–	–	–	–	+	–
Leptorhynchos squamatus (Labill.) Lessing	+	–	–	–	–	+
L. tetrachaetus (Schlechtendal) J. M. Black	–	–	–	–	–	+
Calocephalus citreus Brongn.	+	–	–	–	–	–
Craspedia globosa (Bauer ex Benth.) Benth.	+	+	–	–	–	+
* *Inula graveolens* (L.) Desf.	+	–	–	–	–	+
Myriocephalus rhizocephalus (DC.) Benth.	+	+	–	–	–	+
* *Xanthium spinosum* L.	–	–	–	–	–	+
Eclipta platyglossa F. Muell.	+	+	–	–	–	+
Cotula australis (Sieber ex Spreng.) Hook. f.	–	–	–	–	+	–
* *Arctotheca calendula* (L.) Leyvns.	–	–	+	–	+	–
* *Centaurea repens* L.	–	–	–	–	–	+
* *C. melitensis* L.	–	–	–	–	–	+
Microseris scapigera Forst. f. ex Sch. Bip.	+	–	–	–	–	+
* *Hedypnois cretica* (L.) Willd.	+	–	–	–	–	+
* *Hypochoeris radicata* L.	+	+	+	–	–	+
* *H. glabra* L.	+	+	–	–	–	+
* *Scorzonera laciniata* L.	–	–	–	–	–	+
* *Picris echioides* L.	+	+	+	+	–	+
* *Chondrilla juncea* L.	–	–	–	–	–	+
* *Sonchus oleraceus* L.	+	+	+	+	+	+